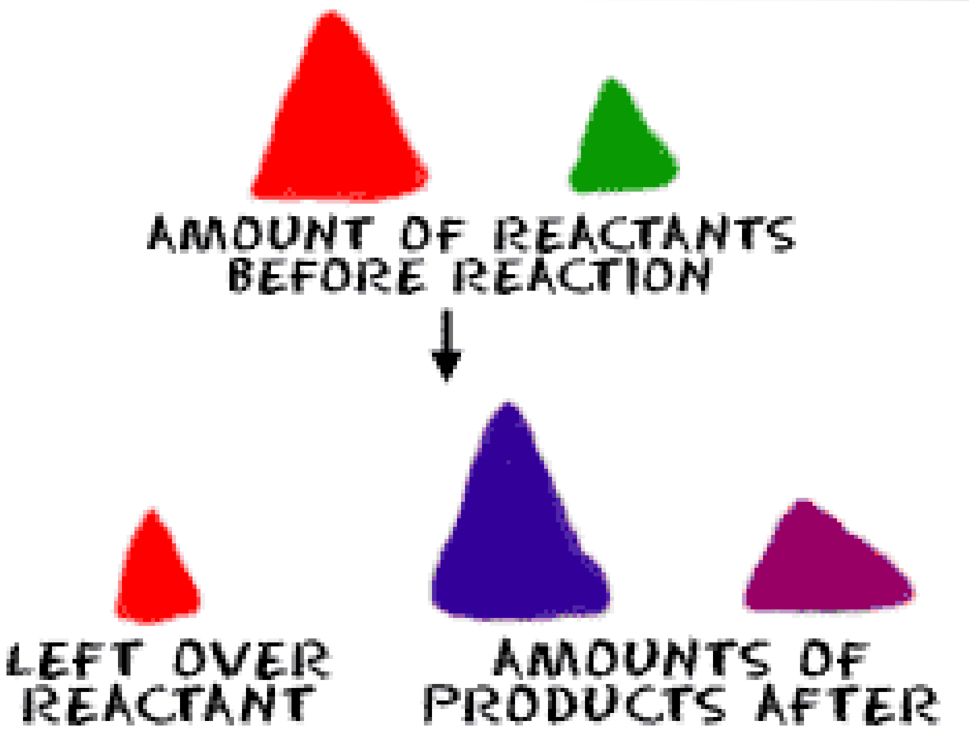
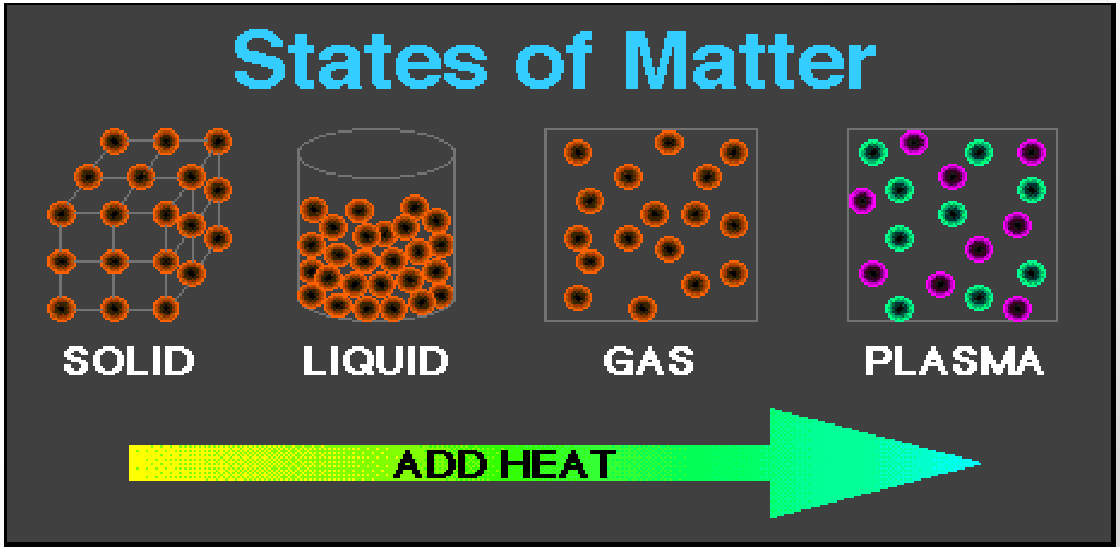
Stoichiometry

- What is matter?
- Can you create it?
- Can you destroy it?

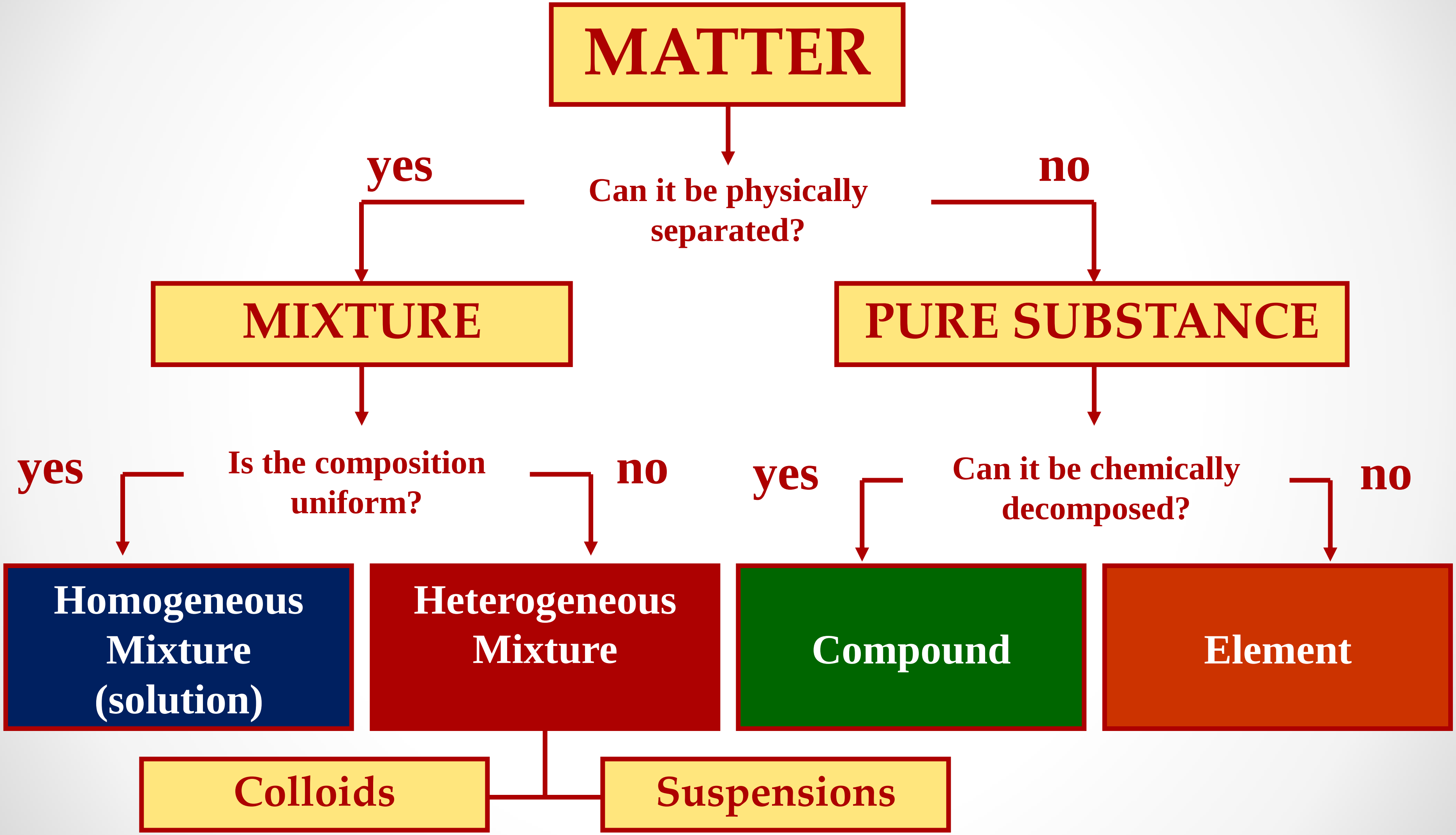


Classification of Matter

- Matter – anything that has mass and takes up space. Anything!
- Chemistry – the study of matter and the changes it undergoes.
- All matter can exist in three (3) states:
  - Solid
  - Liquid
  - Gas
  - Plasma



Matter Flow Chart



The Law of Conservation of Mass

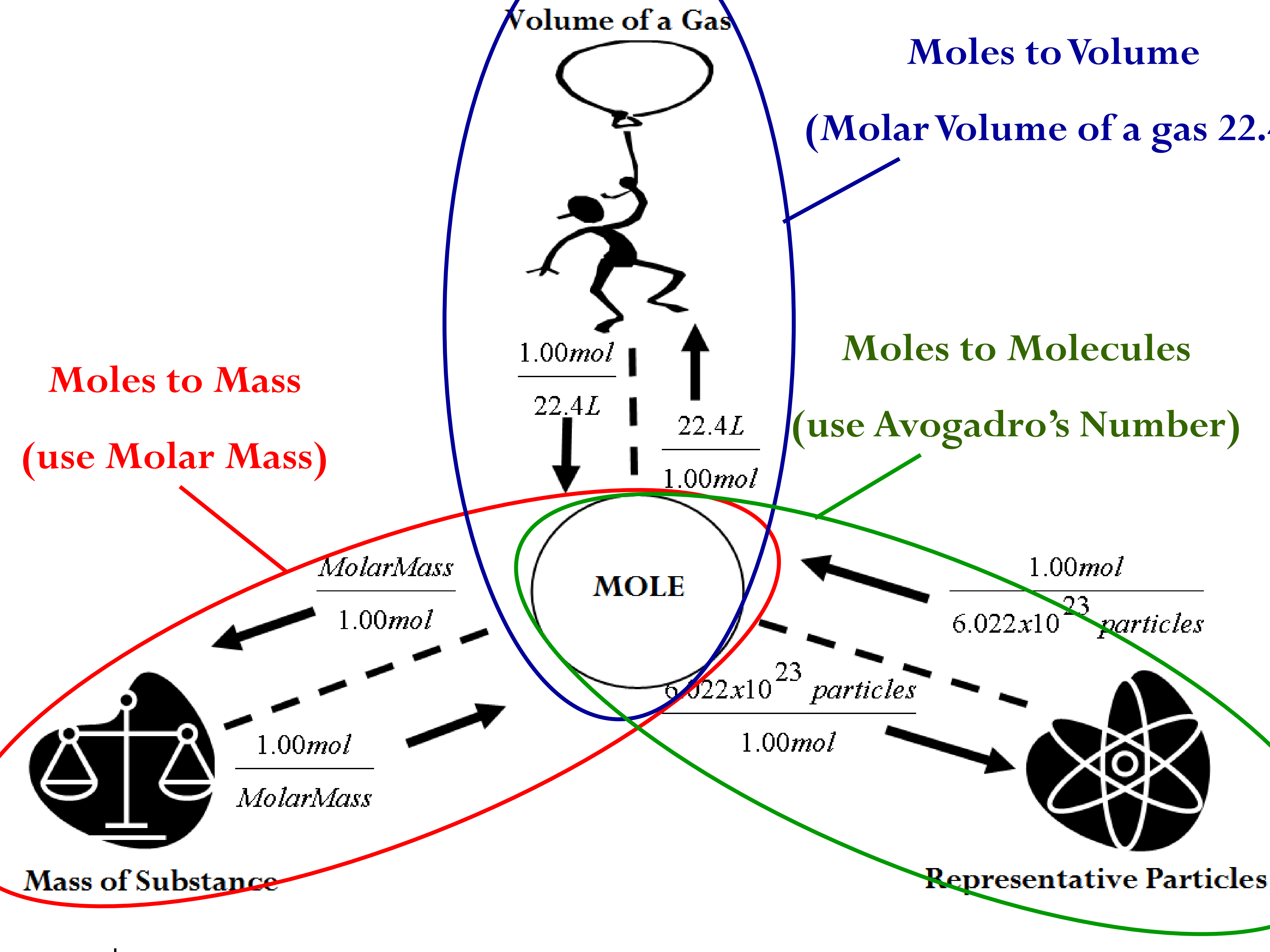
- States that mass is neither created nor destroyed in any ordinary chemical reaction.
- Or more simply, the mass of substances produced (products) by a chemical reaction is always equal to the mass of the reacting substances (reactants).

The Mole

- **Chemical reactions involve atoms and molecules.**
- **The ratios with which elements combine depend on the number of atoms not on their mass.**
- **The masses of atoms or molecules depend on the substance.**
- **Individual atoms and molecules are extremely small. Hence a larger unit is appropriate for measuring quantities of matter.**
- **A <u>mole</u> is equal to exactly the number of atoms in exactly <u>12.0000 grams of carbon 12.</u>**
- **This number is known as Avogadro's number. 1 mole is equal to <u>6.022×10^{23}</u> particles.**

Definitions of the Mole

- **1 mole of a substance has a mass equal to the <u>formula mass in grams</u>.**
- *Examples*
  - *1 mole H_2O is the number of molecules in 18.015 g H_2O*
  - *1 mole H_2 is the number of molecules in 2.016 g H_2.*
  - ***1 mole of atoms has a mass equal to the atomic weight in grams.***
  - ***1 mole of particles = 6.02214 x 10^{23} particles for any substance!***
- The **<u>Molar mass</u>** is the mass of one mole of a substance
- **<u>Avogadro's number</u>** is the number of particles (molecules) in one mole for any substance


Volume of a Gas
Moles to Volume
(Molar Volume of a gas 22.4
1.00mol / 22.4L
22.4L / 1.00mol
Moles to Molecules
(use Avogadro's Number)
Moles to Mass
(use Molar Mass)
MolarMass / 1.00mol
MOLE
1.00mol / 6.022x10^23 particles
6.022x10^23 particles / 1.00mol
1.00mol / MolarMass
Mass of Substance
Representative Particles

Simple Conversions:

- Mole / Mass Conversions -

Use the Molar Mass of a substance to convert from Moles to Mass and Mass to Moles

Mass to Moles →

$$\frac{80.\ \text{g CuSO}_4}{} \left| \frac{1\ \text{mol CuSO}_4}{159.5\ \text{g CuSO}_4} \right. = 0.50\ \text{mol CuSO}_4$$

Moles to Mass →

$$\frac{0.50\ \text{mol CuSO}_4}{} \left| \frac{159.5\ \text{g CuSO}_4}{1\ \text{mol CuSO}_4} \right. = 80.\ \text{g CuSO}_4$$

Simple Conversions:

- Mole / Molecule Conversions -

Use Avogadro's Number : 6.022×10^{23} molecules (mc) in one mole of the substance

Moles to (mc) →

$$\frac{2 \text{ mol } CuSO_4}{} \left| \frac{6.022\text{x}10^{23} \text{ (mc) } CuSO_4}{1 \text{ mol } CuSO_4} \right. = 1.2\text{x}10^{24} \text{ (mc) } CuSO_4$$

(mc) to Moles →

$$\frac{1.2\text{x}10^{24} \text{ (mc) } CuSO_4}{} \left| \frac{1 \text{ mol } CuSO_4}{6.022\text{x}10^{23} \text{ (mc) } CuSO_4} \right. = 2 \text{ mol } CuSO_4$$

Simple Conversions:

- Mole / Volume Conversions -

At STP (standard temperature and pressure) one mole of any gas takes up 22.4 L of space

Moles to Volume →

$$\frac{2 \text{ mol } O_2}{} \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2} = 44.8 \text{ L } O_2$$

Volume to Moles →

$$\frac{44.8 \text{ L } O_2}{} \times \frac{1 \text{ mol } O_2}{22.4 \text{ L } O_2} = 2 \text{ mol } O_2$$

Next Step: Chemical Eqns

- We will write, balance, and predict chemical reactions soon.
- For now the chemical reaction will be give to you, balanced and all.

Mole Ratio

- If you are trying to convert from one material to another in a chemical equation, you must use the mole ratio which can be found in the balanced chemical equation

$$2\,Al + 3\,CuCl_2 \rightarrow 3\,Cu + 2\,AlCl_3$$

- The Mole Ratio for Aluminum to Copper is 2:3 meaning 2 moles of Al will produce 3 moles of Cu, so long as $CuCl_2$ is in excess.

Stoich Problem #1

- If 80 grams of copper (II) sulfate reacts with an excess of iron, how many grams of copper will be produced?

Given: (g CuSO4) Find:(g Cu)

Balanced Eqn: $CuSO_4 + Fe \rightarrow FeSO_4 + Cu$

How to get there: g $CuSO_4$, mol $CuSO_4$, mol Cu , g Cu

80 g $CuSO_4$	1 mol $CuSO_4$	1 mol Cu	63.5 g Cu	= 31.8 g Cu
	159.5 g $CuSO_4$	1 mol $CuSO_4$	1 mol Cu	

Stoich Problem #2

- The base calcium hydroxide neutralizes 60 g nitric acid, how many g of salt will be produced?

Given: (g HNO_3) Find: (g salt)

Balanced Eqn: $2\ HNO_3 + Ca(OH)_2 \rightarrow 2\ H_2O + Ca(NO_3)_2$

How to get there: g HNO_3 , mol HNO_3 , mol $Ca(NO_3)_2$, g $Ca(NO_3)_2$

60 g HNO_3	1 mol HNO_3	1 mol $Ca(NO_3)_2$	160 g $Ca(NO_3)_2$	= 76.2 g $Ca(NO_3)_2$
	63 g HNO_3	2 mol HNO_3	1 mol $Ca(NO_3)_2$	

Stoich Problem #3

- 2.0×10^{25} atoms of copper is reacted with an excess of a silver (I) nitrate solution, how many grams of silver are produced?

Given: (atoms Cu) Find: (g Ag)

Balanced Eqn: $Cu + 2\ AgNO_3 \rightarrow 2\ Ag + Cu(NO_3)_2$

How to get there: atoms Cu , mol Cu , mol Ag , g Ag

2.0×10^{25} (a) Cu	1 mol Cu	2 mol Ag	107.9 g Ag	= 7.17×10^{3} g Ag
	6.022×10^{23} (a) Cu	1 mol Cu	1 mol Ag	

Stoich Problem #4

- An excess of methane gas combusts in the presence of 1.00 kL of oxygen, what volume of carbon dioxide will be produced at STP?

Given: (1 kL O_2) Find: (L CO_2)

Balanced Eqn: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

How to get there: kL O_2 , L O_2 , mol O_2 , mol CO_2 , L CO_2

1.00 kL O_2	1000 L O_2	1 mol O_2	1 mol CO_2	22.4 L CO_2	= 500 L CO_2
	1 kL O_2	22.4 L O_2	2 mol O_2	1 mol CO_2	